PATENT SPECIFICATION

DRAWINGS ATTACHED

1,116,537

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Int. Cl.:—F 28 d 7/10

COMPLETE SPECIFICATION

Heat Exchangers

We, CVI CORPORATION, formerly Cryovac Inc., a corporation of Ohio, United States of America, of Columbus, Ohio, United States of America do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The invention relates to gas counterflow type heat exchangers primarily for cryogenic applications.

In general, the invention relates to improvements in heat exchangers of the type wherein a first gaseous flow is passed through a plurality of coaxially disposed spirally wound tubes and a counterflow of a second gas is passed through the heat exchanger housing in heat exchange relationship with the outer surfaces of the spirally wound tubes.

In accordance with the invention, the heat exchanger is provided with an outer passage construction that conducts the previously mentioned outer counterflow in spiral paths in heat exchange relationship with the outer surfaces of spirally wound tubes.

This passage construction is highly advantageous in that it forces the counterflowing gas to follow relatively long spiral paths as compared to passing the flows along uncontrolled paths extending longitudinally through the exchanger.

As another advantage, the spiral outer passage construction is assembled from materials of low thermal conductivity which insulate, one from another, the adjacently positioned outer paths and thereby eliminate tube to tube heat migration.

As another advantage, the spiral path construction is formed by a series of overlapping arcuate segments which, when assembled, form spirally extending spaced ribbons in combination with flexible filler strips that form mounts for the overlapping spiral segments and which also form an arcuate outer wall for outer passages surrounding the spiral tubes.

[*Price 4s. 6d.*]

It is, therefore, an object of the invention to provide a compact heat exchanger of increased efficiency for any given physical length that incorporates a spirally extending outer passage construction which forces the counterflowing gas to follow spirally extending and thence longer heat exchange paths for any given heat exchanger length.

It is another object of the invention to provide a spiral tube heat exchanger that includes an outer spiral passage construction which conducts the counterflowing gas through relatively long spiral passages that are thermally insulated, one from another, whereby inter-tube heat migration is substantially eliminated.

It is another object of the invention to provide a spiral tube type heat exchanger that combines a maximum in fluid to metal contact with a minimum of pressure drop.

It is another object of the invention to provide a spiral tube heat exchanger that includes a spiral outer passage construction formed of overlapping arcuate segments mounted by flexible filler strips which provide a spirally extending inter passage thermal insulation that can be readily installed in surrounding relationship with tubes of spiral configuration.

The invention is illustrated by way of example in the accompanying diagrammatic drawings in which:—

Fig. 1 is a perspective view of a heat exchanger constructed in accordance with the present invention;

Figure 2 is a broken sectional view, partially in section of a heat exchanger constructed in accordance with the present invention, the section being taken along the vertical plane through the axial centerline of the apparatus;

Figure 3 is a typical partial sectional view showing in detail the outer spiral passage construction of the present invention, the section being taken along a vertical plane through the axial centerline of the exchanger;

Figure 4 is a partial top sectional view of the heat exchanger of the preceding figures,

the section being taken along the line 4—4 of Figure 3;

Figure 5 is an exploded broken perspective view showing the construction of the heat exchanger of the preceding figures, and

Figure 6 is a diagrammatic view showing the parallel circuitry for the spiral tubes of the present heat exchanger.

Referring in detail to the drawings, Figure 1 illustrates a heat exchanger constructed in accordance with the present invention that includes, in Figure 2, an inner tubular core 20 around which is wound an inner layer of three parallel spiral tubes indicated generally at 22.

An inner layer cover 24 surrounds inner layer 22, the latter comprising three individual tubes 26, 28 and 30, best seen in Figure 5 and diagrammatically illustrated in Figure 6.

A second or outer layer of four parallel tubes is generally indicated at 32 and includes individual tubes 34, 36, 38 and 40, said tubes being surrounded by an outer layer cover 42.

Each of the upper ends of the tubes in the inner layer 22 and outer layer 32 are connected to an inlet manifold 44 that is in turn connected to the exterior of the exchanger by an inlet tube 46 and the lower ends of the tubes are connected to an outlet manifold 48 which is in turn connected to the exterior of the exchanger by an outlet tube 50.

The counterflow of gas enters intake tube 51 in chamber 52, said chamber being formed by cover 42. The flow next enters a plurality of outer passages 54, 56 and 58 surrounding each of the inner tubes 26, 28 and 30 and a plurality of outer passages 60, 62, 64, and 66 surrounding each of the outer tubes 34, 36, 38 and 40.

The gaseous counterflow leaves the outer passages via an upper chamber 68 and an outlet tube 70.

Some of the inlets for the outer passages are shown at 72 and 74 in Figure 5 and one of the outlets for these passages is shown at 76 in Figure 2.

Reference is next made to figures 3 and 4 which illustrate in detail the outer passage construction of the present invention which is formed by a spirally extending assembly of overlapping arcuate segments formed of sheet material possessing the property of low thermal conductivity, such as a for example the material available under the trade mark "Micarata." One of these arcuate micarta segments is indicated at 78 in Figures 3 and 4 and includes an end portion 80 in overlapping relationship with an adjacent arcuate micarta segment 84. The inner edge of the segment is mounted in a slot formed in an inner flexible filler strip 86 and an outer edge of the strip is mounted in a slot in an outer flexible filler strip 88. Two such filler strips 86 and 88 are required between adjacently positioned tubes and are formed of synthetic rubber, extruded plastic, or other material which is flexible and which is of low thermal conductivity material.

With continued reference to Figures 3 and 4, each of the spiral tubes, such as tube 36 illustrated in section in Figure 4, includes a plurality of radially outwardly extending metal fins 90 and a plurality of radially inwardly extending metal fins 92 which serve to increase the gas to metal surface contact area, said outer fins 90 serving the additional function of centering the spiral tubes within their respective outer annular passages.

In general, it should be pointed out that in the particular example illustrated, the inner layer of tubes 22 comprises three individual tubes and the outer layer of tubes 32 comprises four individual tubes, the helix angle of the outer tubes being greater than that of the inner tubes. With this arrangement, it will be understood that all of the inner and outer heat exchange paths, extending between the manifolds 44 and 48 will be substantially the same length. Hence, all of the spiral paths will have substantially the same resistance to flow, and the heat exchange load will be equally distributed between the individual tubes.

The heat exchanger of the invention is fabricated by first prewinding each of the inner spiral tubes 26—30 and each of the spiral outer tubes 32—40 around a metal form which is smaller in diameter, by a calculated amount, than their respective final spiral diameter to allow for spring-back of the tubing. One of the inner spiral tubes 30 is next mounted on inner tubular core 20 and one of the inner filler strips 86 is laid in place, in spiral configuration for the entire length of tube 30.

The other inner tubes 26 and 28 are next screwed into a place around core 20 with respective filler strips 86 being successively laid in place between the two.

The overlapping arcuate segments 78 are inserted between the inner tubes with the inner edges of the segments 78 pressed down into the spiral grooves in the inner filler strips 86.

The outer filler strips 86 are next wound in between the inner tubes, with the outer edges of segments 78 disposed in the inwardly facing slots in the outer filler strips 86.

The inner layer cover 24 is next positioned over the inner tubes and the above described assembly steps are next carried out for the outer layer 32 comprising the individual spiral tubes 34—40.

The manifolds 44 and 48, and plates 94, 96 and 98 and the inlet and outlet tubes 50, 51, 46 and 70 are next mounted in place and the outer layer cover 42 is wrapped around the outer layer to complete the assembly.

In operation, the first gaseous flow enters the exchanger at inlet tube 46 and passes through manifold 44 where it is distributed

to the seven inner passages formed by the seven spiral tubes. The inner flow leaves the exits of the seven inner passages via manifold 48 and outlet conduit 50.

The counterflow enters the exchanger at inlet conduit 51, passes through chamber 52 and then enters the outer annular passages surrounding the spiral tubes. This counter flow is released from the exchanger via chamber 68 and outlet conduit 70.

The exchange of heat between the two flows occurs through the walls of the spiral tubes with the flexible strips and spiral micarta segments serving to substantially eliminate heat transfer between the adjacent outer annular passages.

WHAT WE CLAIM IS:—

1. A heat exchanger comprising, in combination, a plurality of inner tubes spirally wound around a common axis and in parallel relationship to one another in the direction of said axis and disposed within a plurality of outer tubes spirally wound in parallel relationship to one another, relative to the said common axis; thermal insulating wall means disposed between each adjacent pair of said inner tubes and forming with the outer surface of said inner tubes separate spirally extending annular passages for conducting return fluid in heat exchange relationship with the outer surfaces of each of said inner tubes; thermal insulating wall means disposed between each adjacent pair of said outer tubes and forming with the outer surface of said inner tubes separate spirally extending annular passages for conducting a fluid in heat exchange relationship with the outer surfaces of said outer tubes; a first manifold operatively connected to said inner and outer spiral tubes for distributing fluid to said inner and outer spiral tubes; a second manifold operatively connected to said inner and outer spiral tubes for collecting the fluid from said inner and outer spiral tubes; a first chamber open to one end of each said annular passages for distributing fluid to said annular passages; and a second chamber open to the opposite end of said annular passages for collecting fluid from said annular passages, each of said thermal insulating wall means including two coextensive flexible filler strips disposed in confronting edge to edge relationship.

2. A heat exchanger as claim in claim 1, wherein said insulating wall means includes a layer of low thermal conductivity material impregnated with a resinous composition disposed between each adjacent pair of said inner tubes and between each adjacent pair of said outer tubes.

3. A heat exchanger as claimed in claim 1, wherein said filler strips are provided with confronting open ended slots; and wherein a spiral layer of low thermal conductivity material is mounted in said open ended slots.

4. A heat exchanger according to any of the preceding claims, wherein said inner and outer tubes include a plurality of fins which extend radially outward from the outer surface of the tubes and wherein said thermal insulating wall means are disposed between the fin ends of each adjacent pair of tubes.

5. A heat exchanger as claimed in claim 2 or claim 3, wherein the layer of low thermal conductivity material comprises a plurality of arcuate segments having overlapping ends.

6. A heat exchanger as claimed in claim 1, wherein said filler strips are provided with confronting open ended slots; and wherein a spiral layer of low thermal conductivity material is mounted in said open ended slots; said thin spiral layer comprising a plurality of arcuate segments having overlapping ends.

7. In a heat exchanger the combination of a plurality of tubes spirally wound in parallel relationship to one another and surrounding an inner wall; thermal insulating wall means disposed between each adjacent pair of said tubes and forming a plurality of spirally extending annular passages each of which surrounds a respective one of said tubes; and an outer wall surrounding said tubes and insulating wall means, each of said thermal insulating wall means including two coextensive flexible filler strips disposed in confronting edge to edge relationship.

8. A heat exchanger as claimed in claim 7, wherein said thermal insulating wall means includes a layer of low thermal conductivity material impregnated with a resinous composition and disposed between each of said tubes.

9. A heat exchanger as claimed in claim 7, wherein said filler strips are provided with confronting open ended slots; and wherein a layer of low thermal conductivity material is mounted in said open ended slots.

10. A heat exchanger as claimed in claim 9, wherein each of said layers of low thermal conductivity material comprises a plurality of arcuate segments having overlapping ends.

11. In a heat exchanger the combination of a pair of tubes spirally wound in parallel relationship to one another about an inner wall, each of said tubes having fins extending radially outwardly from the outer surface of each tube; and a thermal insulating wall means interposed between the outer ends of the fins of adjacent tubes to form separate spirally extending annular passages which surround each of said tubes.

12. A heat exchanger as claimed in claim 11, wherein said thermal insulating wall means includes a spiral layer of low thermal conductivity material impregnated with a resinous composition disposed between adjacent tubes.

13. A heat exchanger as claimed in claim 11, wherein said thermal insulating wall means is formed by spaced flexible spiral filler strips provided with confronting open ended slots; and wherein a spiral layer of low thermal conductivity material is mounted in said open ended slots.

14. A heat exchanger as claimed in claim 12, wherein said layer of low thermal conductivity material comprises a plurality of arcuate segments having overlapping ends.

15. A heat exchanger substantially as hereinbefore described and illustrated in the accompanying drawings.

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3 SHEETS This drawing is a reproduction of the Original on a reduced scale

Sheet 1

FIG.1.

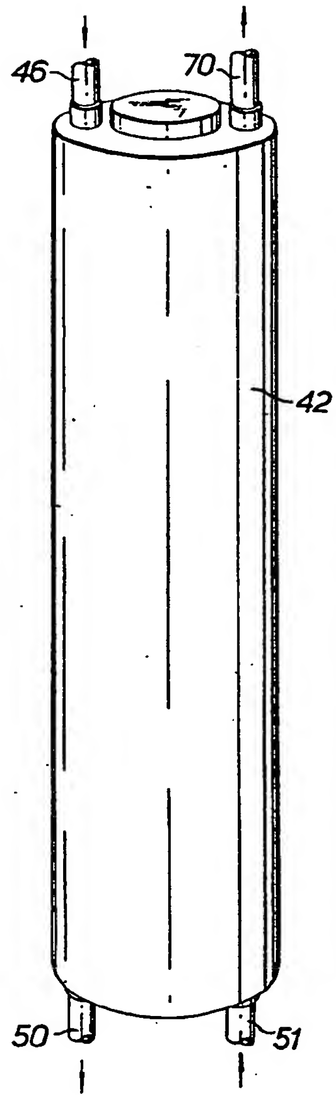


FIG.2.

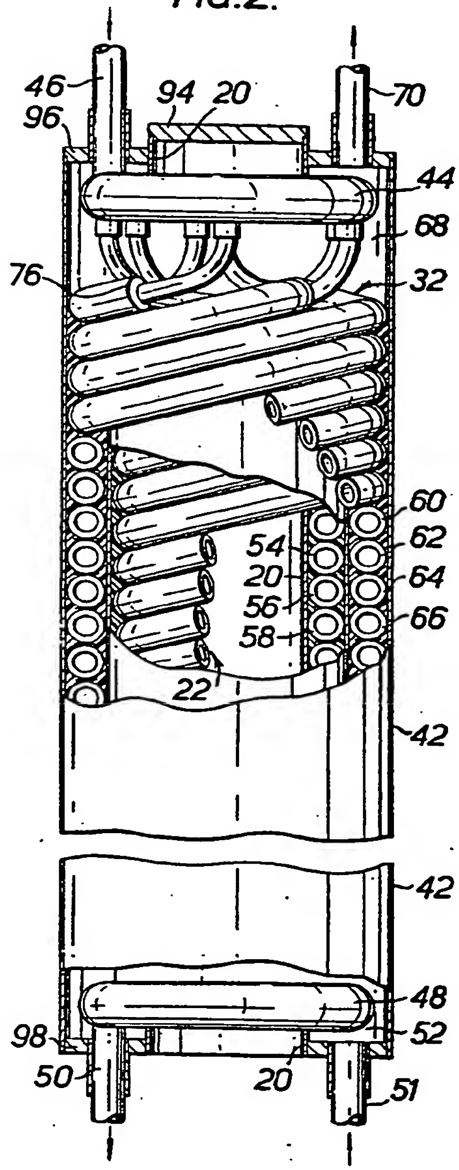
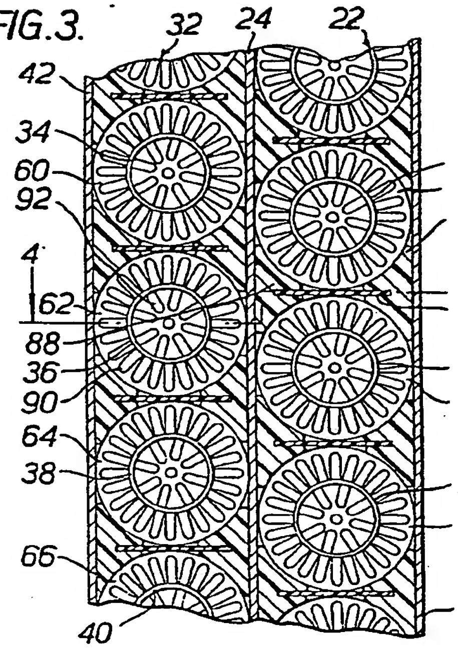
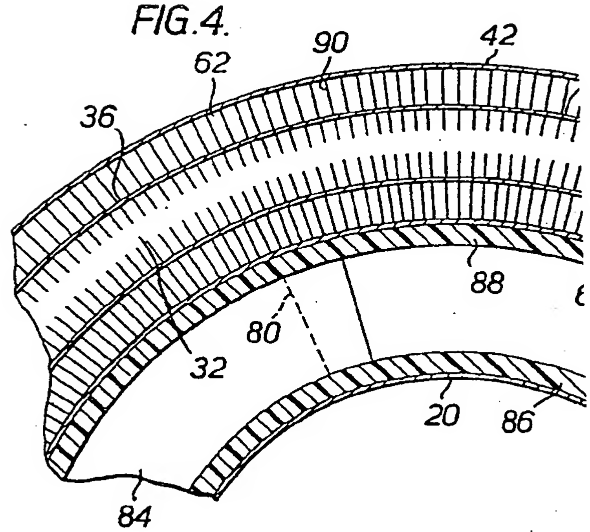


FIG.3.



32
24
22
42
34
60
92
4
62
88
36
90
64
38
66
40

FIG.4.



90
42
62
36
88
80
32
20
86
84

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3 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheets 2 & 3

FIG.5.

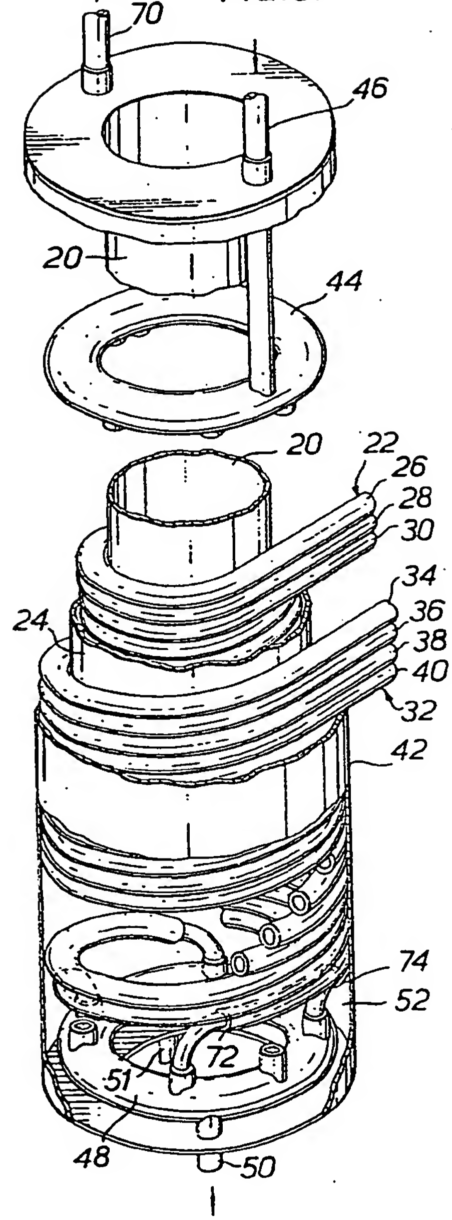
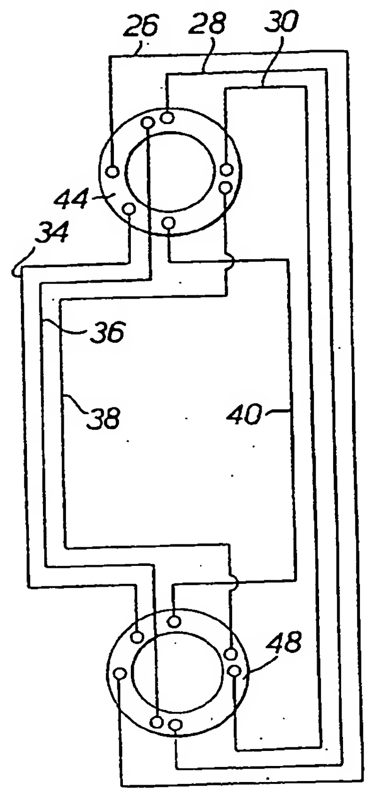
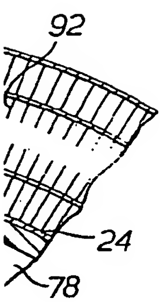


FIG.6.





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3 SHEETS This drawing is a reproduction of the Original on a reduced scale
Sheets 2 & 3

FIG.3.

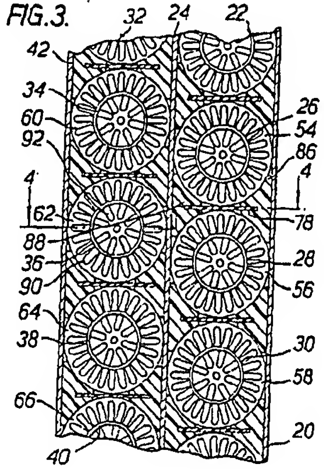

FIG.4.

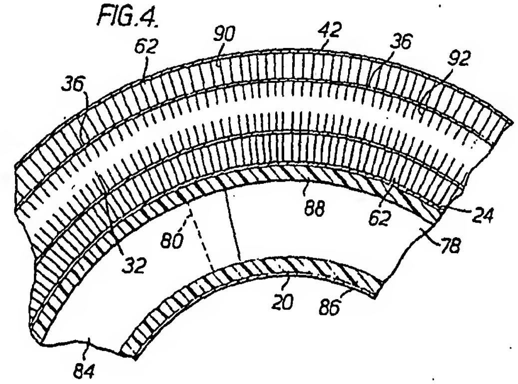

FIG.5.

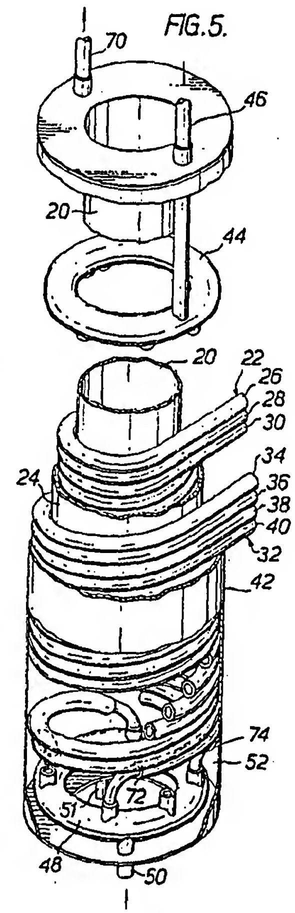

FIG.6.